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Cumulative effects model verification, sustained yield estimation and population variability management of the Kenai Peninsula Alaska Brown Bear

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SUMMARY

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BACKGROUND

The Alaska Department of Fish and Game is responsible for management of the brown or grizzly bear (*Ursus arctos*) on the Kenai Peninsula (KP). We are concerned the viability of this brown bear population may be threatened from increased pressures related to human caused mortality (sport harvest and defense of life or property killing), loss of habitat due to development and logging, and displacement of bears from feeding areas because of increasing recreational activities (primarily salmon fishing). In light of this, we must determine sustained yield for the population, evaluate a cumulative effects model that will allow predictions regarding effects of habitat changes, and develop a long-term management strategy for brown bears on the KP.

The brown bear once ranged from Mexico to the Arctic Ocean and from the Mississippi River to the Pacific Ocean (Rausch 1963). Bear populations south of the Canadian border now exist in only 6 ecosystems, totaling 600-800 individuals. In the continental United States, the brown bear was listed as threatened under the Endangered Species act in 1975 (USDI Fish and Wildlife Service 1982, LeFranc et al. 1987) because it met the following criteria: (1) both present and threatened future destruction and/or modification of habitat; (2) a present loss or potential loss of bears by illegal killing and control actions involving brown bears threatening humans or killing livestock; (3) lack of critical data on brown bear habitat conditions, carrying capacity, population estimates, annual reproduction, mortality, and population trends; and (4) apparent isolation of some existing populations precluding movements from other areas (Servheen 1981).

In Alaska, brown bears range over most of the state and are estimated to number about 31,700 (24,990-39,136) (Miller 1993). In some areas, bear populations and their habitat are declining due to direct human-caused mortality, human encroachment, and habitat alteration.

Little information about brown bear natural history exists, and there is no population estimate for brown bears on the KP. Based on extrapolation from other areas with known bear density, ADF&G and USFWS biologists first estimated the KP population between 150-250 (Jacobs 1989). This estimate was based on the assumption that only 8,800 km^2 of the 23,310 km^2 area on the KP was regularly used as brown bear habitat. More recently, Del Frate (1993) estimated the population at 277 based on the assumption of 13,848 km^2 of habitat and an average density of 20 bears/1000 km^2.

Annual sustainable harvests (allowable human kill) of brown bears are related to reproductive output of the population and natural mortality rates. Using the best available information for the Kenai Peninsula and elsewhere in Alaska, Jacobs (1989) estimated the sustained yield of bears should not exceed 7% of the population. This assumed a natural mortality rate of 5%. Based on a population estimate of 200-300 bears, the allowable harvest should not exceed 14-21 bears, including crippling loss and defense of life or property kills. In the years 1985-91, the total estimated kill on the KP was 18, 18, 12, 13, 7, 14, and 15, respectively.

The harvest of brown bears recently exceeded estimates of sustained yield and hunting seasons have been shortened twice. In 1992, despite a season reduction in 1990, the total annual kill was 27 bears for Units 7 and 15, which encompass the KP. In addition to sport harvest, defense of life or property kills (DLPs) have continued to increase. The season was again shortened for fall 1994 by the Board of Game at their winter meeting in 1993. Because the harvest quota established in the brown bear management plan was exceeded, the fall bear season has been closed by emergency order in 1995, 1996, and again in 1997.

The KP brown bear population is probably isolated from the mainland population. The KP is connected to mainland Alaska by a narrow, 15-km-wide strip of land between Cook Inlet and Prince William Sound. Movement of brown bears through this strip is restricted by human development and physiographic features including 2 communities, 2 airstrips, 13 km of roads, 2 campgrounds, railroad tracks, a 3-km-long lake, and several glaciers. Of approximately 250 gray wolves (*Canis lupus*) marked on the KP over the past 20 years, only 5 have been documented to move off the KP, and marked wolves from elsewhere in Alaska have never been documented to move onto the KP (T. Bailey, pers. commun., KNWR). Brown bears, particularly females, are less inclined to disperse great distances than are gray wolves (Mech 1970, Craighead and Mitchell 1992), indicating that movements of brown bears onto and off of the KP are minimal.

The KP has received some of the most significant human impacts in southcentral Alaska, to the detriment of its wildlife populations and habitats. Gray wolves and caribou (*Rangifer tarandus*) were extirpated by poison and market hunting by 1915, and salmon populations were depressed by over-fishing into the 1950s (Bangs et al. 1982). The human population increased from 24,600 to 43,600 from 1977 to 1987 (Bangs et al. 1982) and is currently estimated at 44,019 (Kenai Peninsula Borough records). Logging, mining, energy development, and water impoundments all occur on the KP and lead to modifications or destruction of habitat for brown bears.

The Kenai Peninsula is the most popular recreation area in Alaska. Each year an estimated 1,000,000 visitor days occur on the KP for camping, fishing, wilderness hiking, and other outdoor-related activities. In response to this pressure, the Kenai National Wildlife Refuge, the Chugach National Forest, and Alaska State Parks are developing or proposing to develop campgrounds, hiking trails, and backcountry hostels to accommodate users. Much of this activity is centered on the Kenai River watershed and the salmon associated with it.

The Kenai Peninsula is experiencing a widespread infestation of spruce bark beetle. Since the 1950s, over 1.2 million of the 2.2 million acres of forest in the Kenai Peninsula Borough have been infected with bark beetle (Hall 1992). The current estimate of active infestation is 397,771 acres (Hennon et al. 1994). In response to this, the state of Alaska, Division of Forestry, and many private citizens are advocating a rigorous timber harvest program including lands important to brown bears. For example, there are about 37,600 acres slated for harvest that have been identified as critical brown bear habitat by Jacobs (1989). With this harvest, many roadless areas will be developed. Logging and bark beetles will ultimately change the forest ecosystem on the KP. The effects of these changes on brown bears are unknown.

The Interagency Brown Bear Study Team (IBBST) was formed by the USFWS, USDA Forest Service, and ADF&G, in 1984, to foster cooperative collection of information needed to manage KP brown bears. The National Park Service joined the effort in 1990. The goal of the IBBST is to develop management strategies to maintain a viable population of brown bears on the KP despite increasing human development and recreation. Research was initiated in 1984 and a draft management plan developed in 1989 (Jacobs 1989). This plan did not include a means to evaluate the effects of human development and habitat modification on brown bears and their habitats. The IBBST next designed a cumulative effects model to assess the effects of management practices on the of habitats to sustain brown bears (Suring et al. 1994).

The cumulative effects model for brown bears on the KP provides an analytical tool to simultaneously evaluate the cumulative effects of human actions on all state, federal, and private lands on brown bear habitat. Habitat capability/cumulative effects models for brown bears have been created for other populations and are being used frequently by land and wildlife management agencies (Christensen and Madel 1982, Christensen 1985, Weaver et al. 1985, Young 1985, Schoen et al. 1994). The brown bear is a management indicator species on both the Chugach National Forest and the Kenai National Wildlife Refuge and represents other animals that require large expanses of relatively undisturbed habitat and quality riparian areas. The direct effects of management activities on the brown bear population on the KP are also a significant management issue.

OBJECTIVES

1. To evaluate a cumulative effects model developed by the Interagency Brown Bear Study Team.

2. To identify critical components of brown bear habitat and movement corridors between these habitats.

3. To estimate the survival rates of radiocollared female brown bears relative to human-caused mortality.

4. Model the brown bear population to establish sustainable yield and assess population viability with the ultimate goal of developing a brown bear management plan.

5. Prepare a final report.

METHODS

Job. 1. To evaluate a cumulative effects model developed by the Interagency Brown Bear Study Team.

Adult female bears were fitted with either conventional or GPS radiocollars (Telonics Inc., Mesa Ariz.). Bears were initially located by air using fixed-wing aircraft, and activity and habitat characteristics noted. Adult bears were immobilized with a combination of tiletamine and zolazepam (Telazol®, Fort Dodge Laboratories, Inc., Fort Dodge, Ia.) at mean dosages of 6.5 mg/kg during spring and 9.8 mg/kg during fall. Bears were darted from a Bell Jet Ranger, Robertson R44, or Hughes 500 helicopter using a Cap-Chur® gun (Palmer Chemical and Equipment Co., Douglasville, Ga.).

Captured bears were examined for injuries, ear tagged, lip tattooed, measured for total length, skull width and length, and chest girth. Blood and hair samples were collected to help determine nutritional condition and health status and establish a genetic data base for future analysis. A premolar was extracted for age determination. Teeth were decalcified and stained using techniques described by Matson (1993) at Matson Laboratories in Milltown, Montana. Age was estimated by counting cementum annuli (Willey 1974, Rogers 1978). Teeth were not extracted from cubs of the year or from most yearlings. Yearlings were aged by comparing the length of the incisor bar to the length of the erupting canine. In almost all cases, the newly erupted canines were shorter than or approximately the same length as the incisors. For our study, cubs were <1 year old, yearlings were $\geq$1 and <2, 2-year-olds were $\geq$2 and $\leq$3. We assumed that parturition occurred in the den sometime in late January or early February, and therefore we set birth dates at 1 February.

Bears that were fitted with GPS transmitters were weighed, and body composition was determined using bioelectrical impediance and isotopic dilution (Farley and Robbins 1994). Bears fitted with conventional collars were handled only once when initially captured. GPS collared bears were handled up to 3 times: at initial capture (May, July, or August), in mid-summer (July or August), and again in late fall (October) when the GPS collar was replaced with a conventional transmitter. In addition, locations of bears indicated by the GPS data were visited on the ground, and evidence of bear activity and habitat conditions was noted. All locations of bears were entered into a GIS, and areas of intense activity and movement corridors were identified.

To test for changes in fix rate over time of GPS collars, we restricted the analysis to 5 collars that were active over the entire season (May-Nov) in 1996. We divided the season in to 10, 15-day periods. Collars were treated as a random variable rather than a fixed variable allowing inference beyond just the 5 collars tested. We used SAS PROC MIXED (Littell et al. 1996) with an Arcsine transformation (arsine (sqrt (p)) (Ostle and Mensing 1975) on proportional data (p = percent of fix attempts that were successful). We used the following approach: (1) specify the model configuration, (2) select a covariance structure, and (3) fit the model. This process was repeated until model fits had the following covariance structure: (1) compound symmetry, (2) first order auto-regressive, (3) antedependence, (4) unstructured, or (5) Toeplitz. Akaile's Information Criteria (AIC) and Schwartz's Bayesian Information Criterion (BIC) were then used to select the best model.

The cumulative effects model was used to predict seasonal locations of brown bears. Bears with conventional collars were tracked at approximately weekly intervals, whereas bears with GPS collars were located via fixed wing aircraft less frequently. At each telemetry fix, we noted the bears' activity, the vegetation type and terrain, photographed the site, and recorded a GPS fix. Data will be analyzed following recommendations of Manly et al. (1993). If the predictions of the cumulative effects model differ from field results, the model will be adjusted based upon the field data. Additional information will then be collected to evaluate changes.

Job. 2. To identify critical components of brown bear habitat and movement corridors between these habitats.

Critical habitat components were identified using radiotelemetry. Although the cumulative effects model identified critical components of habitat, it failed to identify important travel corridors between these components. The locations from GPS transmitters provided these data.

Job. 3. To estimate the survival rate of radiocollared female brown bears relative to human-caused mortality.

To estimate survival rates of female brown bears, we developed a model that divided the year into 2 periods: (1) active period starting 1 May and continuing through 31 October, and (2) the inactive period or denning season encompassing 1 November through 30 April. We defined these periods to satisfy the survival model's requirement of constant survival rates within each period. Although some bears were out of dens during late April and early November, we recorded no deaths during these periods. Data were entered into the model monthly, accounting for newly collared animals and those lost to censoring and death.

Survival and cause-specific mortality were calculated using the Kaplan-Meier procedure (Pollock et al. 1989). Sample size was determined following recommendations presented by Schwartz and Franzmann (1991) for black bears. Their results indicate that a minimum of 19 bears/death must be sampled to be 95% certain the survival estimate is within 10% of the true values. With a survival rate >85% and a censuring rate <15%. this would require approximately 25 bears. If mortality is high (i.e., >15%), we will mark additional individuals.

Job. 4. Model the brown bear population to establish sustainable yields and assess population viability with the ultimate goal of developing a brown bear management plan.

Data obtained from Jobs 1, 2, & 3 were used in a deterministic population model (Miller 1988) to evaluate whether the current level of harvest is within the bounds of a sustainable yield of brown bears. In addition, the computer modeling software GAPPS (Harris et al. 1986) was used to evaluate population changes relative to human-caused mortality. GAPPS is a stochastic model which considers random population variation. Such programming should improve our ability to evaluate population viability and determine consequences of harvest. The modeling program was coordinated with Sterling Miller, ADF&G, Anchorage.

The cumulative effects model was used to identify and/or verify critical components of brown bear habitat previously identified in the management plan published by Jacobs (1989). This management plan is being refined and should ultimately represent a working plan used by all land-management agencies for decision-based resource management.

Job. 5. Prepare a final report.

An annual progress report will be prepared each year with a due date of 31 December. A final report will be prepared at the conclusion of the study on 31 December 1998.

RESULTS AND DISCUSSION

Job. 1. To evaluate a cumulative effects model developed by the Interagency Brown Bear Study Team.

During 1997, 17 new bears (14 females, 3 males) were captured and 24 previously marked bears were recaptured (Table 1) Seventeen females were equipped with GPS collars, 9 of which relayed the data via satellite (ARGOS uplink) and 8 stored the data onboard. The other female bears were equipped with conventional VHF collars. One of the 3 males was fitted with a VHF transmitter.

We tested 9 GPS/Argos collars in 1997. The first GPS fix after initializing the collar occurred at 23:00 GMT. Subsequent fixes were obtained at intervals of 13 hours. The uplink duty cycle was set at 4 h on - 32 h off. The GPS receiver attempted to obtain a position fix at preprogrammed intervals over a 2 minute period. If no fix was obtained, the unit shut off and did not attempt another fix until the next programmed time. Data were stored temporarily on board the collar in a non-volatile storage unit. GPS data were transmitted to a low earth orbiting (LEO) relay satellite constellation, the NOAA/LEO system, at programmed intervals. Fixes were incorporated into the Argos data stream and transmitted from the PTT (platform transmitter terminal) within the collar to the satellite. In this fashion, we used Argos as a data transfer system rather than solely as a positioning system, although we could have used Argos positioning as a backup. Duty cycles, which controlled when the PTT attempted to transmit data to the Argos satellite or was turned off, were chosen to optimize transmission times relative to satellite overpasses of the study area and the angle of a satellite above the horizon (Fancy et al. 1988). During the “on” period of the duty cycles, the PTT transmitted data in approximately 840 millisecond bursts once every 90 seconds. Signals acquired by the satellite (here referred to as an “uplink”) were processed on board, stored to tape, and later transmitted to ground stations (Fancy et al. 1988). We obtained these data from the Argos Data Processing Center in Landover Maryland via telephone modem to a computer in our office in Soldotna, Alaska. With this frequency of fix/uplink transmissions, the collars were designed to deplete the power supply in approximately 4 months. The GPS store-on-board collars attempted GPS fixes at intervals of 5.75 hours (4 or 5 fixes per day). All data were stored within the collar. With this frequency of fixes, these collars also would deplete the power supply in approximately 4 months.

During 1997, we monitored 37 collared bears. These were located via fixed winged aircraft 556 times by air at approximately weekly intervals from March-October, or until they entered dens. In addition, the 9 GPS/Argos collars obtained 1045 location fixes. Performance of the GPS collars was extremely variable. We evaluated the performance of the GPS/Argos collars deployed both in 1996 (n = 10) and 1997 (n = 9; Table 2). When evaluated over the entire field season, success rates for obtaining a GPS fix by individual collars ranged from 10-62% and 25-82% in 1996 and 1997, respectively. Mean locations/collar/season were 50 vs. 116 in 1996 vs.1997, respectively. These differences were caused by different programmed fix rates (23 hrs vs. 13 hrs) between the two years.

When evaluated over both years, successful fix rate decreased significantly (P = 0.0002) over time. We tested this by comparing 15-day periods using arcsine transformed data, which was an order preserving scale. Hence, the trend was also evident on the proportional scale. Based on backward elimination, we were able rule out a reproductive effect (females with cubs vs. yearlings vs. alone). Fix rates were greatest during May and June, declining thereafter, suggesting habitat changes, geographic features, or bear behavior reduced performance. Brown bears on the Kenai Peninsula generally move to salmon streams to feed on fish in early July.

Uplink success with the ARGOS satellite was similar to the GPS fix rate, ranging from 13-63% and 30-96% in 1996 and 1997, respectively (Table 2). We detected a highly significant correlation (P <0.01, r = 0.91) between the proportion of successful GPS fixes and the successful Argos uplinks (Fig. 1). Rates of successful uplinks by individual collars ranged from 12-65%. Success rates were greatest during May and June, and declined during July and August, again suggesting that habitat changes, geographic features, or bear behavior reduced performance when bears moved to salmon streams.

We combined data from 1996 with 1997 to evaluate the GPS store-on-board collars. Successful fix rate ranged from 50-74% (Table 3). Because units attempted multiple fixes per day, there were very few days (3%) when no fix was obtained (Fig. 2). Our success rate for GPS fixes with the store-on-board collars ($\underline{x}$ = 66.7%) was significantly higher ($\underline{t}$ = -4.009, $\underline{P}$ < 0.001) than the success rate for the GPS-Argos system ($\underline{x}$ = 43.1%). This difference suggests that some data from the GPS-Argos units may have been lost due to failed uplinks. The tradeoff is the possibility of lost data if the collar is not retrieved. This has not happened to date; however, we did lose contact with a GPS/Argos-equipped bear in September 1997, for unknown reasons.

All GPS data have been analyzed and two manuscripts were prepared accepted for presentation at the 1998 IBA conference.

Aerial location data have been entered into a database for future analysis. Each location was photographed from the air to confirm vegetation type and the percentage of beetle-killed spruce. We have been unsuccessful to date in obtaining a Peninsula-wide GIS data layer of vegetative cover. Plans are underway to contract development of the map and we should begin Resource Selection analysis during the next report period. At this time, however, no progress was made relative to this objective.

Several of the females were captured 2 or 3 times, in May, July-August, and October, to assess body condition and obtain blood and hair samples for a graduate study by Grant Hilderbrand of Washington State University. Results of that project are presented in Appendix A.

Job. 2. To identify critical components of brown bear habitat and movement corridors between these habitats.

We catalogued each location point for bears located with VHF transmitters to specific habitat type, using the Viereck system (Viereck et al. 1992) of habitat classification. In addition, each location was photographed for further classification and confirmation as needed. Vegetation descriptions and codes have been incorporated into a database for future analysis.

We deployed GPS store-on-board transmitters to aid in the identification of critical travel corridors near the Skilak Lake area on the Kenai National Wildlife Refuge. The Interagency Brown Bear Study Team identified the area west of Skilak Lake as a potentially important travel corridor for brown bears. This area was deemed important because it represented the last undeveloped tract of lowland habitat in this area connecting the large wilderness area on the northern refuge to the Andy Simons Wilderness Area between Skilak and Tustumena Lakes. The land west of this corridor is in private ownership and rapidly being developed (Fig.3).

In addition to being an important movement corridor, the area below Skilak Lake has been identified as an important salmon spawning area where numerous bears come to feed. Bears appear to rely heavily on dead or dying salmon that have already spawned. These fish concentrate on gravel bars and below bends in the river. We have been working with the local legislative office through ADF&G to develop a critical habitat designation for bears (see Appendix B). Movements of other radiocollared bears during late August-September also support our contention that this area is important to brown bears. In 1996 and again in 1997, there was a large number of spawning red salmon just below Skilak Lake in the Kenai River.

This area was very important to brown bears for feeding, particularly female bears with offspring. On one day in 1996, we located 12 radiocollared adult females with a total of 20 offspring: this is 32 known different bears in an area of about 10 square miles. Use was somewhat lower in 1997 because of flood stage conditions in this area of the river during the period when bears normally feed here. A large glacier lake dumped its water load, causing the flooding. High water washed many of the fish carcasses out of the area, reducing the normally abundant supply of fish. After the water level dropped to normal levels, bears again moved into the area. This area was used by females with cubs from August through November, with the most intensive use in late-October. Several females were still active in the area during early November. Combining both 1996 and 1997, we found that at least 14 radio marked bears and several unmarked bears used the area.

In 1997 we also witnessed a high level of use of the Kenai River above Skilak lake, where the river empties into the lake and on nearby Hidden Creek. Locations of radio-marked bears indicate that this area is also an important travel corridor and bear feeding area (Fig. 3). Data from 1996 and 1997 indicated that 8 radio-collared bears and several unmarked bears used this area. We recommend no new development in this area, particularly anywhere along Hidden Creek and at the confluence of the Kenai River with Skilak Lake. We also recommend that the Kenai National Wildlife Refuge consider discouraging overnight camping along the banks of the Kenai River from Skilak Lake upstream for approximately 1.5 miles. Camping should be provided at suitable sites along the north shore of Skilak Lake, west of the confluence with the river in sections 22, and 24-25. Refuge staff should work closely with the IBBST to ensure that brown bears are not displaced from critical feeding areas both above and below Skilak Lake.

Bear locations during both 1996 and 1997 show that the Killey River provides a significant food source and travel corridor from the wilderness habitats between Skilak and Tustumena Lakes to the Kenai River. We had several bears move along this stream. Most of the land in the lower 2 miles of both forks of the Killey is currently in private ownership. To date, little development has occurred on these lands. One large platted subdivision of 160 acres is located right in the middle of this travel corridor. This area has been included within the boundaries of the Critical Habitat Area (CHA). Although legislation for CHA's only impacts state-owned lands, it is our intention to focus attention on this private parcel. If this area becomes developed with recreational or residential housing, it will become a major bear sink (place where bears are killed by humans). Bears traveling down the Killey to the Kenai will be forced to travel through a development. An analysis of Defense of Life and Property Kills (DLP's) (Appendix C) from the Kenai Peninsula shows that about 1/3 of all bears killed by people are shot in defense of property at a residence. Improper handling and disposal of garbage, fish waste, livestock offal, dog food, and other foods, plus most types of confined livestock act to attract bears into residential areas. Residential development in this area has the potential to impact a significant portion of the entire Kenai brown bear population. We have documented nearly every marked bear from unit 15B and most from 15A traveling to this ecocenter to feed. The Killey River represents the major travel corridor for bears moving from the mountains between Skilak and Tustumena Lakes to the Kenai River. Consequently, we strongly recommend that these parcels be purchased and protected. The need to act immediately in purchasing these lands is amplified by the newest proposal to complete the bridge across the Kenai River connecting the Sterling Highway via Scout Lake Road to the Funny River Road. Such a bridge will increase human activities, real estate development, and defense of life and property killing in this area.

During 1996 and 1997, at least 3 bears used both the inlet and outlet at the 2 ends of Skilak Lake. Radio locations for bear number 12 were obtained from a store-on-board GPS unit. This bear moved between the two ends of the lake along the north shore (Fig. 4). We did not obtain enough locations to document the exact path taken by the other two bears moving between these two areas. However, all location points of these bears were on the north side of the lake.

Movements of bears in both 1996 and 1997 were used to identify areas that represented potential travel corridors connecting large blocks of undisturbed habitat. In 1996, we identified the ends of the large lakes as travel corridors. We have identified several new corridors based upon movements recorded in 1997 (Fig. 5). Several of these travel routes follow important salmon spawning streams, and thus are also important feeding areas for bears.
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The first bears entered dens during mid-September, and the last entered dens during late November. Of 12 bears collared during both 1995 and 1996, 7 denned in virtually identical locations in both years. Of the others, 3 denned within 3 miles of their previous dens, 1 denned about 5 miles away, and 1 denned 12 miles away. Bears denned in both mountainous areas and lowland forests. Documentation of radio-collared bears denning in the lowland forests is a new finding; previous studies of brown bears on the Kenai (Jacobs 1989) indicated they denned in rugged mountainous terrain.

Part of the long-term management of the Russian River ecosystem for humans and bears must contain a plan to make human use compatible with brown bear conservation. Certain sections or areas in the ecosystem must be identified as “bear only areas”, most will be identified as “bear and people” areas, and some will ultimately be classified as “people only” areas. For example, Russian Creek (also referred to as Goat Creek) has been identified as a critical bear ecocenter (here we use the term originally defined by Craighead et al. 1995:322, to refer to areas where bears concentrate at a food source) during the month of August. Bears from much of Unit 15B and parts of Unit 7 migrate here to utilize the spawning red salmon. Human activity in this area is increasing as tourism and sport fishing encroach in Russian Creek. Because of this, we will propose to close the area to sport fishing when bears are using the area. (Appendix D).

The Russian River above the intensive salmon fishery should be managed as a “bear and people” area, whereas the area intensively used by fishermen should probably be managed as a “people only” area, where the presence of brown bears will be discouraged. We conducted a user survey (Appendix E) to determine (Appendix F) attitudes of Russian River anglers relative to brown bear conservation, and anglers’ willingness to change certain activities relative to the fishery and fish waste management. This survey had a confidence level of 95%. Annually there are problems with brown bear-human conflicts. These encounters are a direct result of fishers recycling fish waste into the Russian/Kenai River after harvesting red salmon. The recycling is encouraged by ADF&G Sport Fish Division to return nutrients to the aquatic system where they are used by rearing salmon and trout. This creates an unnatural food source, because historically, bears probably did not fish for red salmon in these sections of the Russian and Kenai Rivers. In these stretches of river, the fish are not vulnerable to bear predation because of the depth of the river, the glacial silt in the Kenai, and the lack of concentrations of fish. In the past, bears probably used the area below the Russian River Falls as a feeding area, but human activity now precludes use by bears. Results of the survey are presented in Appendix G.

Job. 3. To estimate the survival rate of radiocollared female brown bears relative to human-caused mortality.

We had 3 mortalities in 1997. One bear (12) was found dead near the Kenai River where it enters Skilak Lake. She moved to this location on 9-13-97. When examined, the carcass had been consumed by maggots. All that remained was hair and bones. One rear leg was disarticulated from the carcass and moved approximately 50 meters away, evidently by a scavenging coyote. The bones showed no sign of chewing by either small or large carnivores. We examined the carcass using a metal detector, but no bullet was found. All bones were visually inspected; none were broken. There were no apparent signs to indicate cause of death. Cause of death was recorded as unknown. Female 997 was hit by a train on 9-7-97 5 miles north of Moose Pass while defending a moose carcass also killed by a previous train. Female 65 was killed in Defense of Life near Lonely Street and Tote Road (Unit 15B) by a moose hunter. The hunter reportedly encountered the bear at close range on a foggy trail.

We calculated Kaplin-Meyer survival coefficients for active and denning periods for 1995, 1996, and 1997 data (Table 4). Annual rates did not differ between 1995 and 1996 ($\underline{X}^2 = 0.165$, $\underline{P} = 0.685$) or between 1996 and 1997 ($\underline{X}^2 = 0.566$, $\underline{P} = 0.452$), so we pooled data from the three years (Table 5). Survival from May through October was 0.909 (95% CI = 0.846-0.973). We did not observe any mortality from November-April, so survival was 1.0 during the denning period.

Our estimate of annual survival was slightly higher during 1997 than that reported last year (although the difference was not statistically significant). This was expected, because in 1996 we had only 15 marked bears and recorded 1 death during the month of May, resulting in a substantial initial drop in survival. The pooled estimate of survival for the active bear season (May-October) represents a better estimate with about a 33% tighter confidence interval $\pm$ 0.064 vs. $\pm$ 0.0963. With additional years of data, our estimates of survival will continue to improve.

Job. 4. Model the brown bear population to establish sustainable yield and assess population viability with the ultimate goal of developing a brown bear management plan.

We continued to refine our estimates of reproductive histories (Table 6) of marked bears. Data are still inadequate at this time to model the Kenai population**.** We observed 38 litters of cubs of the year. Mean litter size was 2.32. These litters comprised 2 singles (5.2%), 22 twins (57.9%), and 14 triplets (36.8%). We also observed 27 litters of yearlings. These litters comprised 4 singles (14.8%), 17 twins (63.0%), and 6 triplets (22.2%). Mean litter size was 2.07 yearlings.

During the 1995-1997 field seasons we observed 84 cubs of the year, 53 yearlings, and 13 2-year-olds. At least 65 COY and 29 yearlings survived until the next year. All 2-year-old cubs were presumed to have dispersed by June of their third year. Including cubs with unknown fates, we estimated survival of cubs to the yearling age class to be between 0.77 and 0.89. Likewise, survival of yearlings to the 2-year-old age class was between 0.55 and 0.81. These estimates must be refined prior to any modeling exercise. We provide them for comparative purposes and to show that we may be experiencing a very high rate of yearling mortality.

Job. 5. Prepare a final report.

No work was performed on this job during this report period.

RECOMMENDATIONS

This project is scheduled to run a minimum of 3 years. We recommend continuing data collection through summer field season of 1998.

We also have the following recommendations:

- Develop a conservation strategy for brown bears on the Kenai Peninsula. The IBBST should take the lead in the scientific data analysis and document preparation. Recommendations for why such a strategy is necessary can be found in Appendix H.
- Consider development of a new field study to evaluate mortality in yearling brown bears.
- Consider development of a new field study in cooperation with Dr. Charles Robbins at Washington State University to evaluate the impacts of reduced usage of salmon feeding areas by bears due to human disturbance. A study design could consider using the 8 GPS store-on-board transmitters programmed to take multiple fixes/day (i.e., every 30 minutes) for a short period (i.e., 1 month). Collars would be used to evaluate the temporal usage of streams for bears impacted by human activity (i.e., Goat Creek, Kenai River) vs. bears not disturbed by humans (i.e., Glacier Creek, Bear Creek). Body composition and mass change should be monitored in conjunction with temporal usage to evaluate fat deposition rates. The overall objective of the study would be to determine if bears are capable of obtaining the necessary mass to reproduce and survive the winter when disturbed by humans.
- The cumulative effects model should be tested using the 1995-1997 telemetry locations. Following this test, those model variables that are incorrect should be changed to reflect the test. The new improved model should be verified using 1998 location data. This process should be lead by Lowell Suring of the U.S. Forest Service. Results should be incorporated into the next annual report.
- The physical locations of each Defense of Life and Property Kill should be coded to the Uniform Coding Unit (UCU) if known and a GIS data layer developed with an attribute file containing the descriptive records from each recorded kill. This file should be used to evaluate the locations of DLP's relative to roads, human development, and access points for hunters. Gino Del Frate, ADF&G should prepare the UCU map and work in close cooperation with Lowell Suring, USFWS, to do the analysis. Results should be incorporated into the next annual report.
- Once the vegetation GIS layer is developed, resource selection analysis should be performed. An example protocol established for Kenai black bears (Appendix I) lays out the basics for the analysis.
- Continue with the Russian River/Kenai River campground survey in 1998 to complete the sample. The instrument is presented in Appendix J.

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Table 1 Brown bear radiocollaring and tagging status by sex and age, Kenai Peninsula 1995-1997.

Bear No.	Capture Date	Sex	Age	Tagging Location	Accompanying Bears	Transmitter Type	Last Date Located	Current Status
01	5/19/95	F	3	UPPER MOOSE. CR	alone	Conventional	7/13/95	dead, brown bear predation
02	5/19/95	F	4	TIMBERLINE LK	alone	Conventional	12/3/97	denned
03	5/19/95	F	3	TIMBERLINE LK	With # 02	Conventional	6/2/95	shed collar
04	5/22/95	F	13	BALD MT. S. SIDE	2 yearlings	GPS-PTT*	12/3/97	denned
05	5/30/95	M	13	5 MI S. BIG BAY	alone	Conventional	6/2/95	shed collar
06	5/30/95	F	3	BEAR CREEK	alone	Conventional	5/1/97	shed collar
07	5/30/95	M	1	UPPER MOOSE CREEK	alone	None	5/30/95	unknown
08	5/30/95	M	1	UPPER MOOSE CREEK	alone	None	5/30/95	unknown
09	5/31/95	F	7	N. TIMBERLINE LK	alone	Conventional	12/3/97	denned
11	5/31/95	F	12	W. KILLEY RIVER	3- c.o.y.	Conventional	5/22/97	active
12	5/31/95	F	16	SKILAK GLACIER	3-2 yr. olds	GPS-stored*	10/8/97	dead, cause unknown
13	6/2/95	F	7	HW. COTTONWOOD CR	alone	Conventional	12/3/97	denned
14	6/5/95	F	7	GOAT LAKE	2-yearlings	Conventional	12/3/97	denned
15	6/5/95	F	20	GOAT LAKE	2- c.o.y.	Conventional	12/3/97	denned
16	6/5/95	F	5	EMMA LAKE	alone	Conventional	5/7/96	denned
17	6/8/95	M	2	FOREST LANE	alone	Conventional	6/8/95	unknown
18	6/9/95	F	7	CARIBOU HILLS	2 2-year olds?	Conventional	8/10/95	shed collar
19	6/20/95	F	5	S. SIDE MT. ADAIR	2- c.o.y.	Conventional	12/3/97	denned
20	7/26/95	M	0	PIPELINE		None	7/26/95	unknown
21	8/14/95	F	8	GLACIER CREEK	1- c.o.y.	Conventional	12/3/97	denned
22	10/4/95	F	3	GLACIER FLATS	alone	Conventional	5/7/96	dead, cause unknown
23	4/30/96	M	3	CHICKALOON FLATS	alone	None	4/30/96	capture mortality
24	4/30/96	F	7	ELEPHANT LAKE	3- c.o.y.	GPS-PTT*	12/3/97	denned
25	5/6/96	M	4	CARIBOU HILLS	alone	None	5/6/96	unknown
26	5/16/96	M	12	CARIBOU HILLS	alone	Ear tag	6/4/96	unknown
27	5/16/96	M	4	CARIBOU HILLS	alone	None	5/16/96	unknown

Table 1 .Continued

Bear No.	Capture Date	Sex	Age	Tagging Location	Accompanying Bears	Transmitter Type	Last Date Located	Current Status 2
8	5/17/96	F	8	BALD MOUNTAIN	3 cubs	GPS-PTT*	10/10/96	shed collar
29	5/17/96	F	6	ANCHOR RIVER	2- c.o.y.	GPS-PTT*	12/3/97	denned
30	5/19/96	F	9	TRUULI CANYON	2 yearlings	GPS-PTT*	10/8/96	dead - shot?, not confirmed
31	5/20/96	F	10	MYSTERY CREEK	3- c.o.y.	Conventional	8/14/97	shed collar
32	5/21/96	F	8	FALLS CREEK	3- c.o.y.	Conventional	12/3/97	denned
33	5/22/96	F	7	THURMAN CREEK	1-yearling	GPS-stored*	12/3/97	denned
34	5/22/96	F	2	DIKE CREEK	2- c.o.y.	Conventional	12/3/97	denned
35	5/22/96	M	2	DIKE CREEK	alone	None	5/22/96	unknown
36	5/23/96	M	10	MYSTERY CREEK	alone	Ear tag	5/28/96	unknown
37	5/28/96	F	8	SKILAKE OUTLET	3- c.o.y.	Conventional	12/9/97	denned
38	5/29/96	M	6	SHAFT CREEK	with #32	Ear tag	11/1/96	denned
39	7/1/96	F	6	TUSTUMENA BENCH	alone	Conventional	4/3/97	denned
40	7/15/96	F	13	MYSTERY CREEK	2-yearlings	Conventional	12/9/97	denned
41	7/16/96	F	9	MOOSE CREEK	2-yearlings	Conventional	12/3/97	denned
42	7/16/96	F	10	SLIKOK LAKE	2-yearlings	GPS-stored*	12/9/97	denned
44	10/17/96	F	15	SKILAK OUTLET	3-c.o.y.	Conventional	7/30/97	shed collar
45	10/17/96	F	10	SKILAK OUTLET	3-yearlings	Conventional	12/3/97	denned
46	10/17/96	F	10	SKILAK OUTLET	2-yearlings	GPS-stored*	12/3/97	denned
47	10/22/96	F	8	SKILAK OUTLET	2-yearlings	Conventional	12/3/97	denned
48	10/22/96	F	10	SKILAK OUTLET	alone	Conventional	4/3/97	denned
49	10/22/96	F	8	SKILAK OUTLET	1-yearling	GPS-stored*	12/9/97	denned
50	10/22/96	M	1	SKILAK OUTLET	alone	Conventional	10/6/97	shed collar
51	5/11/97	F	15	DEEP CREEK	alone	GPS-PTT*	12/3/97	denned
52	5/16/97	F	10	THURMAN CREEK	alone	GPS-PTT*	5/18/97	shed
53	5/16/97	F	3	MYSTERY HILLS	alone	Conventional	5/21/97	shed
54	5/16/97	F	6	GOLD GULCH	alone	GPS-PTT*	12/3/97	denned
55	5/18/97	F	13	HILL 26	3-c.o.y.	GPS-PTT*	12/3/97	denned

Table 1 .Continued

Bear No.	Capture Date	Sex	Age	Tagging Location	Accompanying Bears	Transmitter Type	Last Date Located	Current Status 5
6	5/18/97	M	0	NOT RECORDED	unknown	None	00/00/00	unknown
57	5/18/97	M	3	NOT RECORDED	unknown	None	00/00/00	unknown
58	5/19/97	F	10	ICE LAKE	1-c.o.y.	GPS-PTT*	12/9/97	denned
59	5/20/97	F	8	NOT RECORDED	3 yearlings	GPS-PTT*	12/3/97	denned
60	5/20/97	F	12	NOT RECORDED	2 yearlings	GPS-PTT*	8/29/97	missing
61	5/30/97	F	12	NOT RECORDED	2-c.o.y.	Conventional	12/3/97	denned
62	5/30/97	F	5	SHAFT CREEK	alone	Conventional	12/3/97	denned
63	5/31/97	F	8	GRANT LAKE	alone	GPS-stored*	12/3/97	denned
64	6/2/97	M	15	NOT RECORDED	unknown	None	00/00/00	unknown
65	7/18/97	F	3	FUNNY RIVER	alone	Conventional	9/2/97	dead, recorded DLP
66	9/10/97	F	7	HIDDEN CREEK	2-c.o.y.	Conventional	12/9/97	denned
67	9/10/97	F	6	HIDDEN CREEK	2-c.o.y.	Conventional	12/3/97	denned
68	9/11/97	F	12	JOHNSON CREEK	2-c.o.y.	Conventional	12/3/97	denned
69	10/6/97	F	11	FOX RIVER	alone	Conventional	12/3/97	denned
70	10/8/97	F	7	UPPER RUSSIAN LAKE	2-c.o.y.	Conventional	12/3/97	denned
71	10/13/97	F	8	UPPER RUSSIAN LAKE	3-c.o.y.	Conventional	12/3/97	denned
72	10/13/97	F	10	UPPER RUSSIAN LAKE	2-c.o.y.	Conventional	12/3/97	denned
997	5/30/97	F	10	SHAFT CREEK	alone	GPS-stored*	9/2/97	dead, hit by train

*GPS-PTT collars contain satellite transmitters; GPS-stored collars stored location data on-board. GPS collars were replaced with conventional collars during September - October 1997, except for bear #32, who was already in a den.

Table 2. Success rates for good fixes and uplinks for GPS-Argos transmitters deployed on brown bears on the Kenai Peninsula, Alaska, 1996 and 1997. GPS units were programmed to take 1 fix every 23 hours in 1996 and every 13 hours in 1997.

PTT #	Days Deployed	Fixes (n)	Percent Fixes	Possible Uplinks (n)	Actual Uplinks (n)	Percent Uplinks
10911	101	29	29	41	9	22
10916	93	44	47	37	20	54
10918	146	70	48	58	28	48
10919	164	72	44	65	27	42
10920	147	91	62	59	37	63
10921	147	63	43	59	25	42
10922	145	36	25	58	18	31
10923	116	64	55	46	25	54
10924	94	21	22	38	9	24
10925	94	10	11	37	5	13
1996 Total	1247	500	38(16)[1]	498	203	39(16)[1]
10911	148	140	47	100	48	48
10916	148	119	40	100	43	43
10918	124	61	25	84	25	30
10919	146	96	33	98	36	37
10920	62	54	44	43	35	81
10921	114	94	41	77	37	48
10922	117	117	50	79	46	58
10924	141	198	70	95	74	78
10925	101	166	82	68	65	96
1997 Total	1101	1045	48(18)[1]	744	409	58(22)[1]
Both Years	2348	1545	43[2]	1242	612	48[2]

[1]Weighted by PTT, standard deviation in parentheses.
[2]Weighted by year.

Table 3. GPS fix rate for store on board collars deployed on brown bears on the Kenai Peninsula, Alaska, 1996 and 1996. GPS units were programmed to take 5 fixes/day.

Year	Days Deployed	Potential Fixes (n)	Actual Fixes (n)	Percent Fixes	Days Fixed	Percent Days Fixed
1996	142	593	299	50	127	89
1996	87	367	246	67	86	99
1997	162	674	423	63	155	96
1997	170	705	521	74	169	99
1997	152	630	389	62	146	96
1997	176	732	528	72	168	96
1997	104	431	250	58	103	99
1997	137	568	401	71	136	99
1997	101	418	267	64	98	97
Total	1231	5118	3324	65[1]	1188	97[1]

[1]Weighted by GPS unit.

Table 4. Annual Kaplin-Meyer survival estimates for female brown bears on the Kenai Peninsula. Survival was based on a year which began on 1 November and ended 31 October, except in 1995 when the study began.

Period	Year	Month	At Risk	Deaths	Censors	Captures	Survival	Lower	Upper
1	1995	06	8	0	1	6	1.00000	1.00000	1.00000
1	1995	07	13	1	0	0	0.92308	0.78391	1.00000
1	1995	08	12	0	1	2	0.92308	0.77822	1.00000
1	1995	09	13	0	0	0	0.92308	0.78391	1.00000
1	1995	10	13	0	0	1	0.92308	0.78391	1.00000
2	1995	11	14	0	0	0	1.00000	1.00000	1.00000
2	1995	12	14	0	0	0	1.00000	1.00000	1.00000
2	1996	01	14	0	0	0	1.00000	1.00000	1.00000
2	1996	02	14	0	0	0	1.00000	1.00000	1.00000
2	1996	03	14	0	0	0	1.00000	1.00000	1.00000
2	1996	04	14	0	0	1	1.00000	1.00000	1.00000
3	1996	05	15	1	1	8	0.93333	0.81138	1.00000
3	1996	06	21	0	0	0	0.93333	0.83026	1.00000
3	1996	07	21	0	0	4	0.93333	0.83026	1.00000
3	1996	08	25	0	0	0	0.93333	0.83887	1.00000
3	1996	09	25	0	0	0	0.93333	0.83887	1.00000
3	1996	10	25	1	1	6	0.89600	0.78273	1.00000
4	1996	11	29	0	0	0	1.00000	1.00000	1.00000
4	1996	12	29	0	0	0	1.00000	1.00000	1.00000
4	1997	01	29	0	0	0	1.00000	1.00000	1.00000
4	1997	02	29	0	0	0	1.00000	1.00000	1.00000
4	1997	03	29	0	0	0	1.00000	1.00000	1.00000
4	1997	04	29	0	1	0	1.00000	1.00000	1.00000
5	1997	05	29	0	3	11	1.00000	1.00000	1.00000
5	1997	06	37	0	3	0	1.00000	1.00000	1.00000
5	1997	07	34	0	0	1	1.00000	1.00000	1.00000
5	1997	08	35	0	3	0	1.00000	1.00000	1.00000
5	1997	09	32	2	0	3	0.93750	0.85629	1.00000
5	1997	10	33	1	0	4	0.90909	0.81557	1.00000
6	1997	11	36	0	0	0	1.00000	1.00000	1.00000
6	1997	12	36	0	0	0	1.00000	1.00000	1.00000

Table 5. Non-denning period Kaplin-Meyer survival estimates for female brown bears on the Kenai Peninsula from May through October. Survival estimated for years 1995-1997 were not significantly different ($P < 0.05$) so all years are combined. See text for details.

MONTH	AT RISK	DEATHS	SURVIVAL	LOWER	UPPER
5	44	1	0.97727	0.93374	1.00000
6	66	0	0.97727	0.94173	1.00000
7	69	1	0.96311	0.91946	1.00000
8	72	0	0.96311	0.92038	1.00000
9	70	2	0.93559	0.87997	0.99122
10	71	2	0.90924	0.84552	0.97295

Table 6. Reproductive status of radiocollared brown bears on the Kenai Peninsula Alaska, 1993-1997. Bears were collared beginning in 1995. Question marks indicating unknown litter sizes are back projections based upon the reproductive status of the female at time of capture. COY are cubs of the year, 1YR are yearlings, and 2YR are 2-year-old offspring; numbers of offspring are listed in parentheses.

Bear ID	Birth Year	1993	1994	1995	1996	1997	Comments
01	1992			0			DEAD 7/95
02	1991	COY(?)	1YR(?)	2YR(1)	COY(2)	1YR(2)	
03	1992			0	LOST		
04	1982		COY(?)	1YR(2)	COY(2)	1YR(2)	NOTE 1
06	1992			0	0	0	SHED 5/97
09	1988		COY(?)	1YR(2)	COY(3)	1YR(3)	NOTE 1
11	1983			0	COY(3)	1YR(3)	SHED 6/97
12	1979			COY(3)	1YR(3)	2YR(3)	DEAD 9/97
13	1988			0	COY(2)	1YR(2)	
14	1988		COY(?)	1YR(2)	2YR(2)	COY(2)	
15	1975	COY(?)	1YR(?)	2YR(2)	0	COY(2)	
16	1990		COY(?)	1YR(2)	2YR(2)		SHED 5/96
18	1988	COY(?)	1YR(?)	2YR(2)			SHED 8/95
19	1990			0	COY(2)	COY(2)	
21	1987		COY(?)	1YR(2)	0	COY(1)	NOTE 2
22	1992			0	0		DEAD 5/96
24	1987				COY(3)	COY(3)	NOTE 3
28	1986				COY(3)		SHED 10/96
29	1991			COY(?)	1YR(1)	COY(2)	
30	1984			COY(?)	1YR(2)		DEAD 10/97
31	1978			COY(?)	1YR(3)	COY(3)	NOTE 4
32	1987				0	COY(3)	
33	1991				COY(2)	1YR(1)	
34	1994				0	0	
37	1983				0	COY(3)	
39	1989			COY(?)	1YR(2)		SHED 5/97
40	1977				COY(2)	1YR(2)	
41	1987				COY(2)	1YR(2)	
42	1988				COY(2)	1YR(2)	
44	1988				0	COY(3)	SHED 8/97
45	1988				COY(3)	1YR(3)	
46	1986				COY(2)	1YR(2)	
47	1982				COY(2)	1YR(2)	
48	1989				COY(3)	0	
49	1990				COY(1)	1YR(1)	
51	1981					0	
52	1985			COY(?)	1YR(?)	2YR(1)	SHED 6/97
53	1995					COT(2)	SHED 6/97
54	1990			COY(?)	1YR(?)	2YR(2)	
55	1987					COY(3)	
58	1989				COY(?)	1YR(1)	
59	1991				COY(?)	1YR(3)	
60	1987				COY(?)	1YR(2)	
61	1990					COY(2)	

Table 6. Continued.

Bear ID	Birth Year Comments	1993	1994	1995	1996	1997	
_							
62	1994					0	
63	1991					COY(2)	
65	1995					0	DEAD
9/97							
66	1990					COY(2)	
67	1992					COY(2)	
68	1986					COY(2)	
69	1990					0	
70	1991					COY(2)	
71	1989					COY(3)	
72	1987					COY(2)	
997	1993				0	0	DEAD
9/97							

NOTES:
1. ‘95 yearlings were never seen after the mother was captured.
2. ‘95 yearlings were seen with the mother after capture (Jul-Aug) but not seen in ‘96.
3. Ages of bears 24-49 were estimated in the field based on tooth eruption and wear.
4. 96 yearlings were never seen after the mother was captured, #31 shed collar 8/97

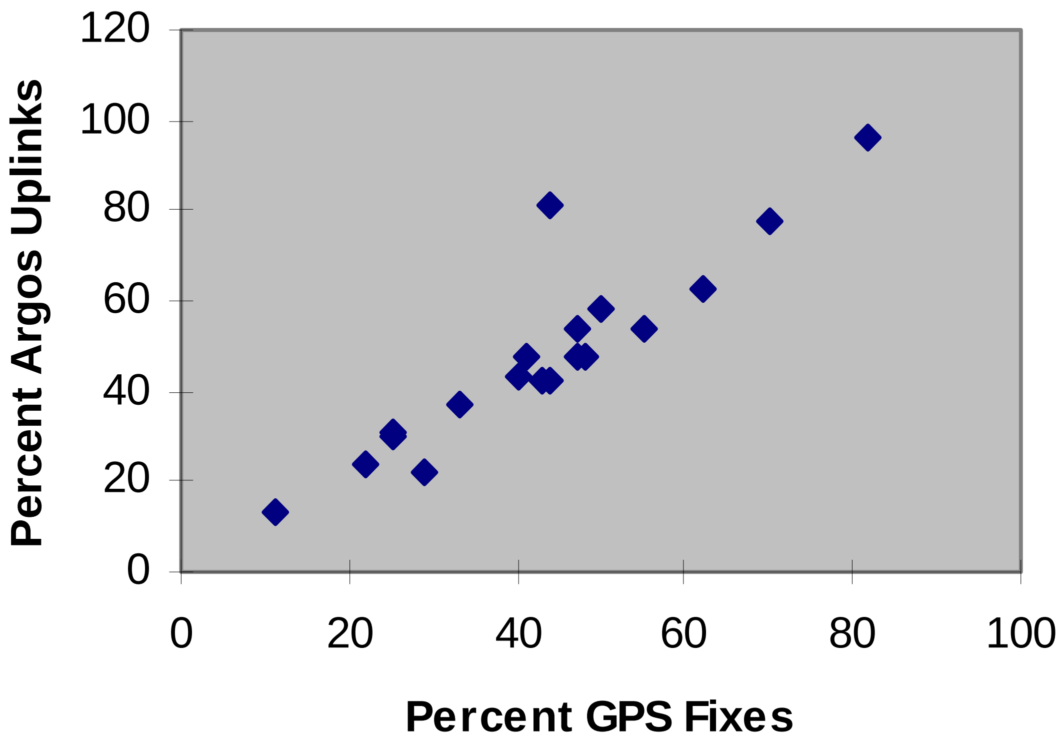

Figure 1. Relationship between the percentage of successful GPS fixes and successful Argos uplinks. Data are from GPS-Argos collars deployed in both 1996 ($\underline{n}$ = 10) and 1997 ($\underline{n}$ = 9), respectively.

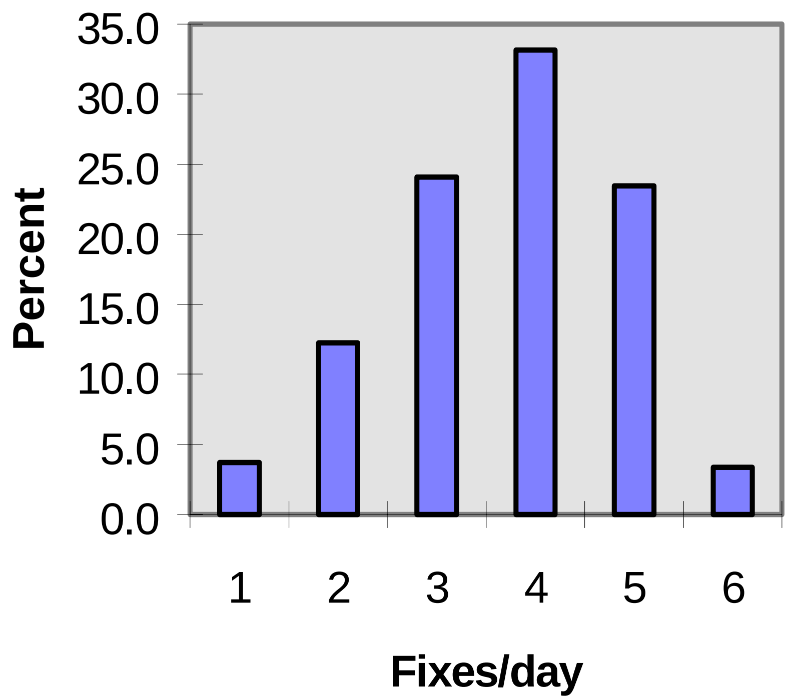

Figure 2. Distribution of actual GPS fixes obtained from the GPS-store on board collars programmed to take 5 fixes per day.